Spacecraft Onboard Interface Standardization in CCSDS

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Agenda

- CCSDS structure and Strategic Themes
- Purpose and Goals for the Spacecraft Onboard Interface task
- The Subsystem Perspective of SOIF
- The Communications Protocols for SOIF
- Issues

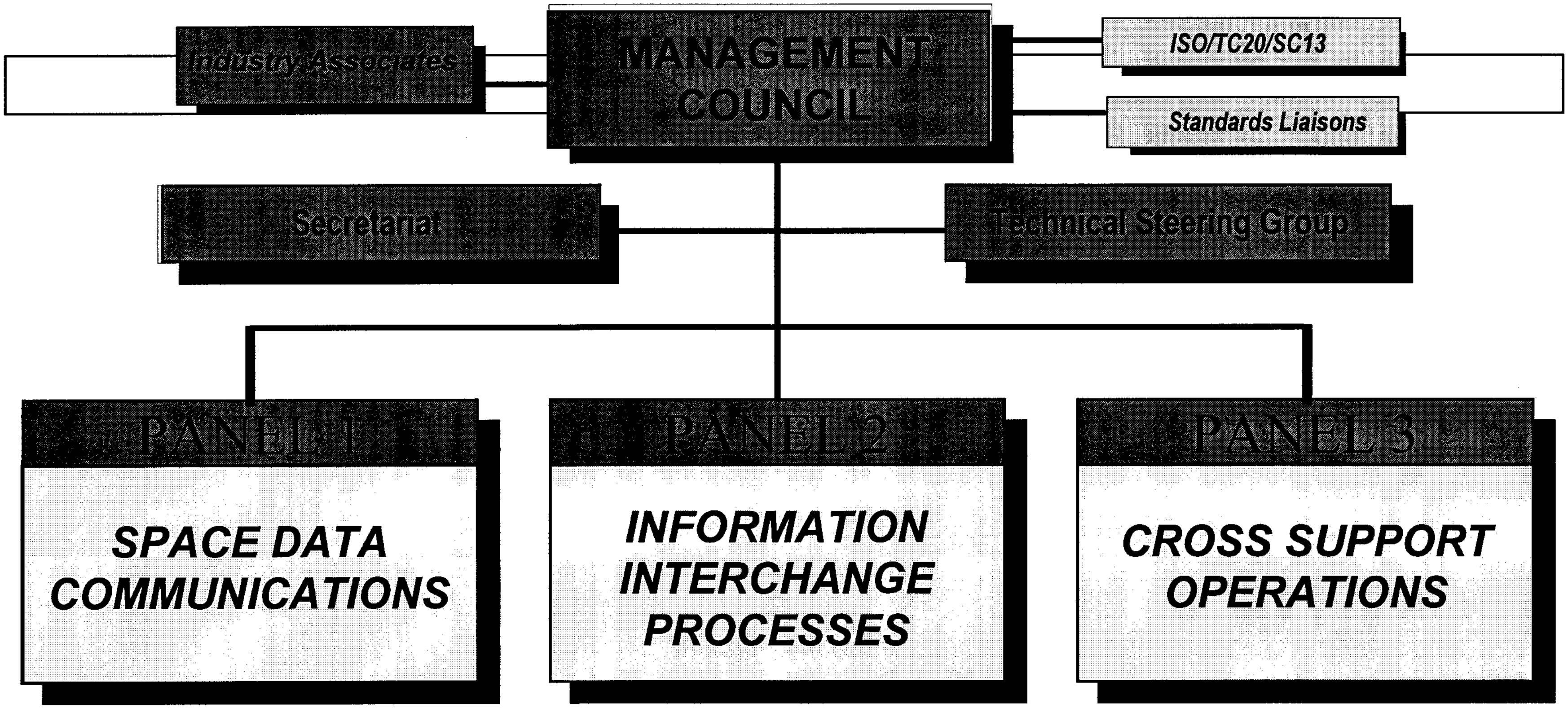
The research described in this presentation was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Spacecraft Onboard Interface task for CCSDS

- Consultative Committee for Space Data Systems (CCSDS) is an international organization of national space organizations
  - NASA is the U. S. member of CCSDS
- The purpose of CCSDS is to create international standards for inter-operability of space missions, and to ease dissemination of space derived scientific data
- CCSDS has created standards for
  - Space communications
  - Data interchange and archiving
  - Standard mission operations services
  - Internet type protocols for space missions
- These standards are well entrenched in many space programs
- Recent interest has been in new area for standardization of onboard interfaces
  - This is called Spacecraft Onboard Interfaces (SOIF) and is the subject of most of this presentation

Consultative Committee for Space Data Systems (CCSDS)

http://www.ccsds.org



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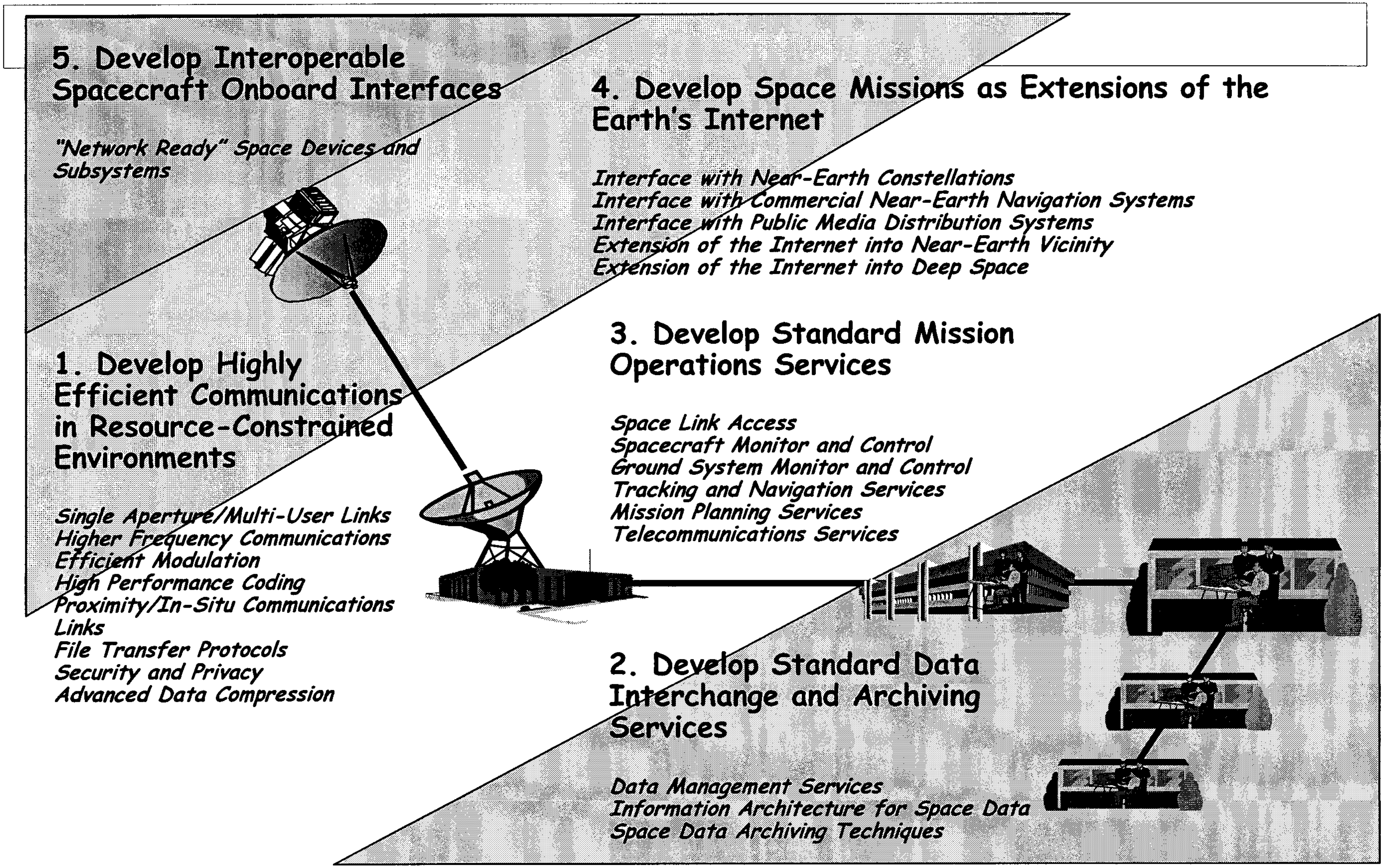
CCSDS Strategic Themes



Purpose of Spacecraft Onboard Interface (SOIF)

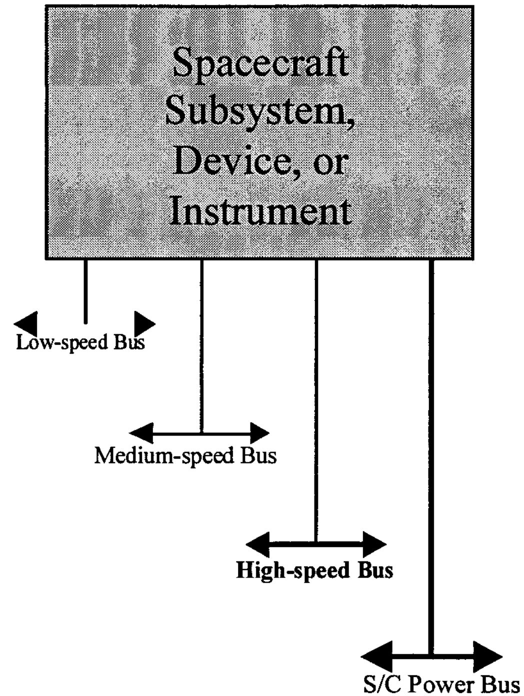
- Lack of standards has lead to each new project to redesign its onboard interfaces
  - This leads to use of resources to perform the same work
  - Resources could be better spent on enhancing the functionality and technology of new missions
  - Projects should spend time and resources on making missions better, instead of on the same old interfaces
- Purpose is to standardize the onboard hardware and software interfaces
  - Projects only need to worry about interface implementation, not design
  - Will allow for reuse of interface designs in different missions
- Will be performed by the Consultative Committee for Space Data Systems (CCSDS)
  - CCSDS creates recommendations, which are used by projects as needed

A Future Vision based on SOIF Success

- The proposed SOIF recommendation will produce the following benefits:
  - Reduce flight system development costs
  - Reduce flight system development and integration time
  - Reduce flight and test system documentation
  - Encourage rapid insertion of new technologies (through layering)
  - Increase flight and test system reuse and reliability
  - Improve test systems and spacecraft simulators
  - Better support secondary and quick-ride payload development
  - Encourage development of truly standard spacecraft devices and elements
  - Encourage second-source of flight and test system hardware and software
- This will allow the use of the standard interfaces for science instruments and subsystems
- Spacecraft hardware devices will also be able to use the appropriate interface standard

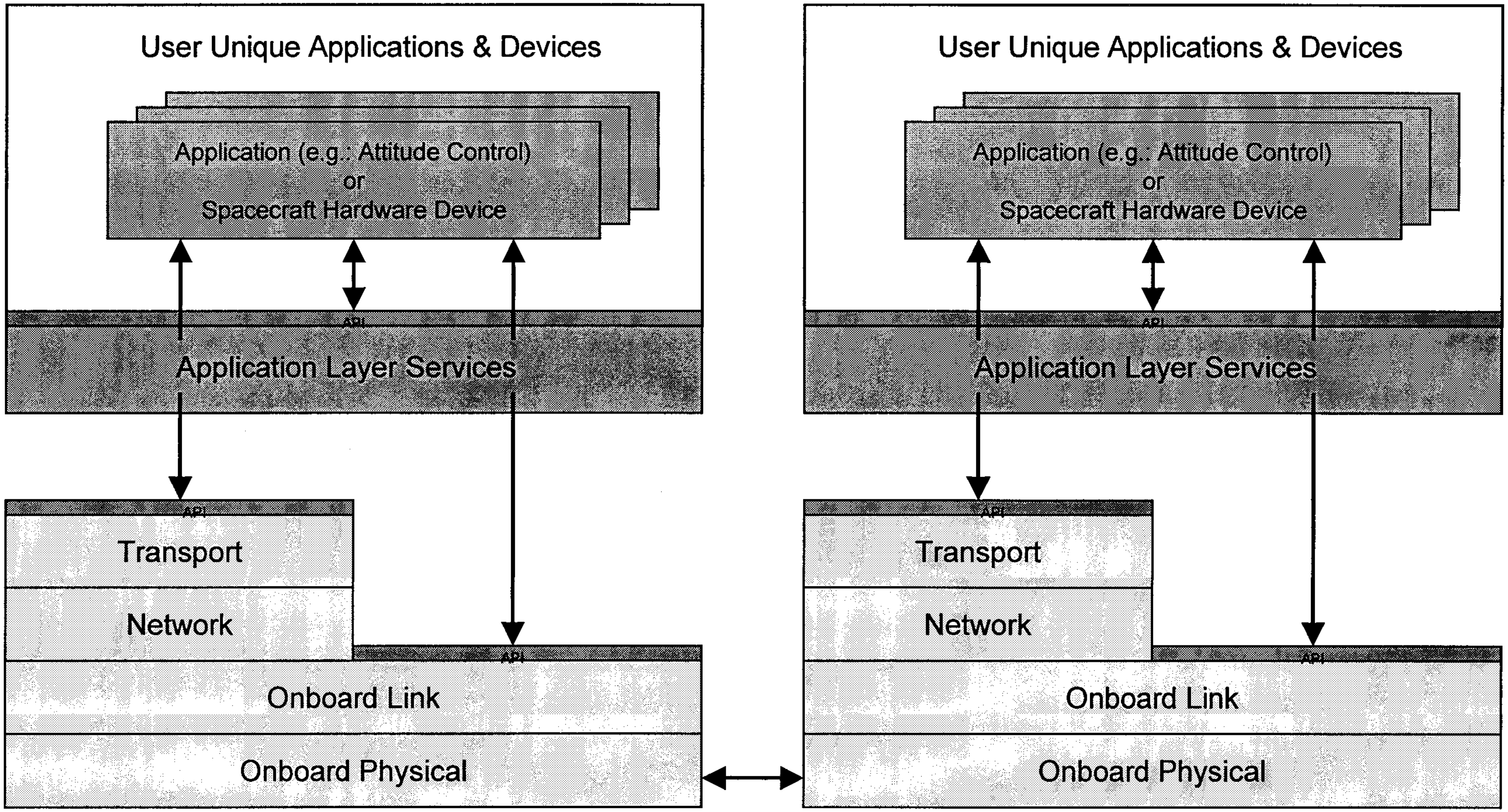
The Subsystem or Device Perspective

- From the perspective of the instrument or subsystem
  - All external electrical interfaces can be met with the set of standardized interfaces
  - Power standard selected for spacecraft & instrument/subsystem needs
  - Use of high-, medium-, and/or low-speed busses meet all instrument/subsystem needs, using one or more of the three selected busses
- Only standardized interfaces are to be tested during vehicle integration & test, placing all unique I/Fs (if used) inside instrument/subsystem



Subsystem/Device/Instrument perspective of the SOIF implementation

Communications for Applications & Devices



Communications will be between a pair of applications, or between an application and a spacecraft device

SOIF WEB Site

- ESA Web site address for the Spacecraft Onboard Interface task at: ftp://ftp.estec.esa.nl/pub/ws/wsd/ccsds/ccsdsoif/intro.htm

BACKUP SLIDES

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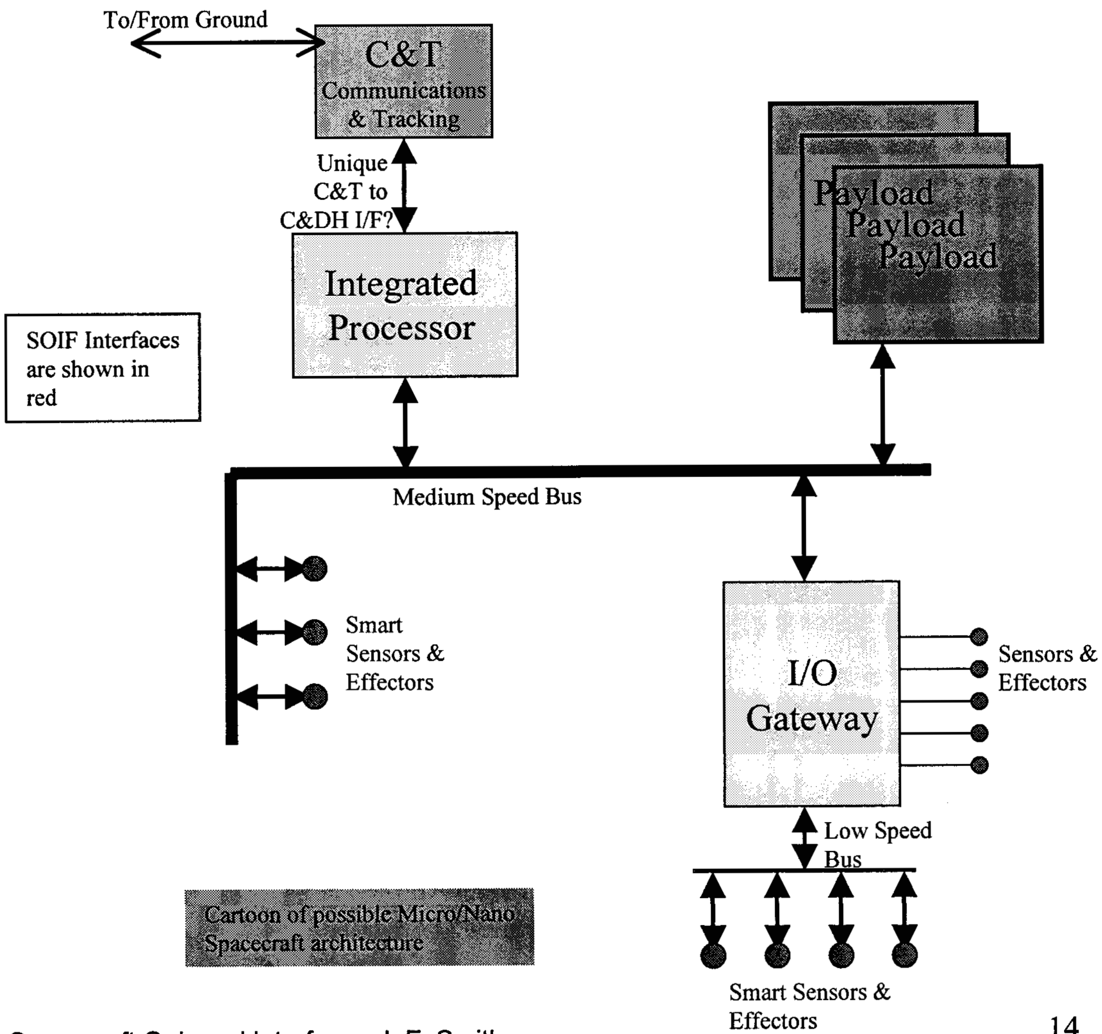
Physical Context of the SOIF: Micro/Nano Spacecraft

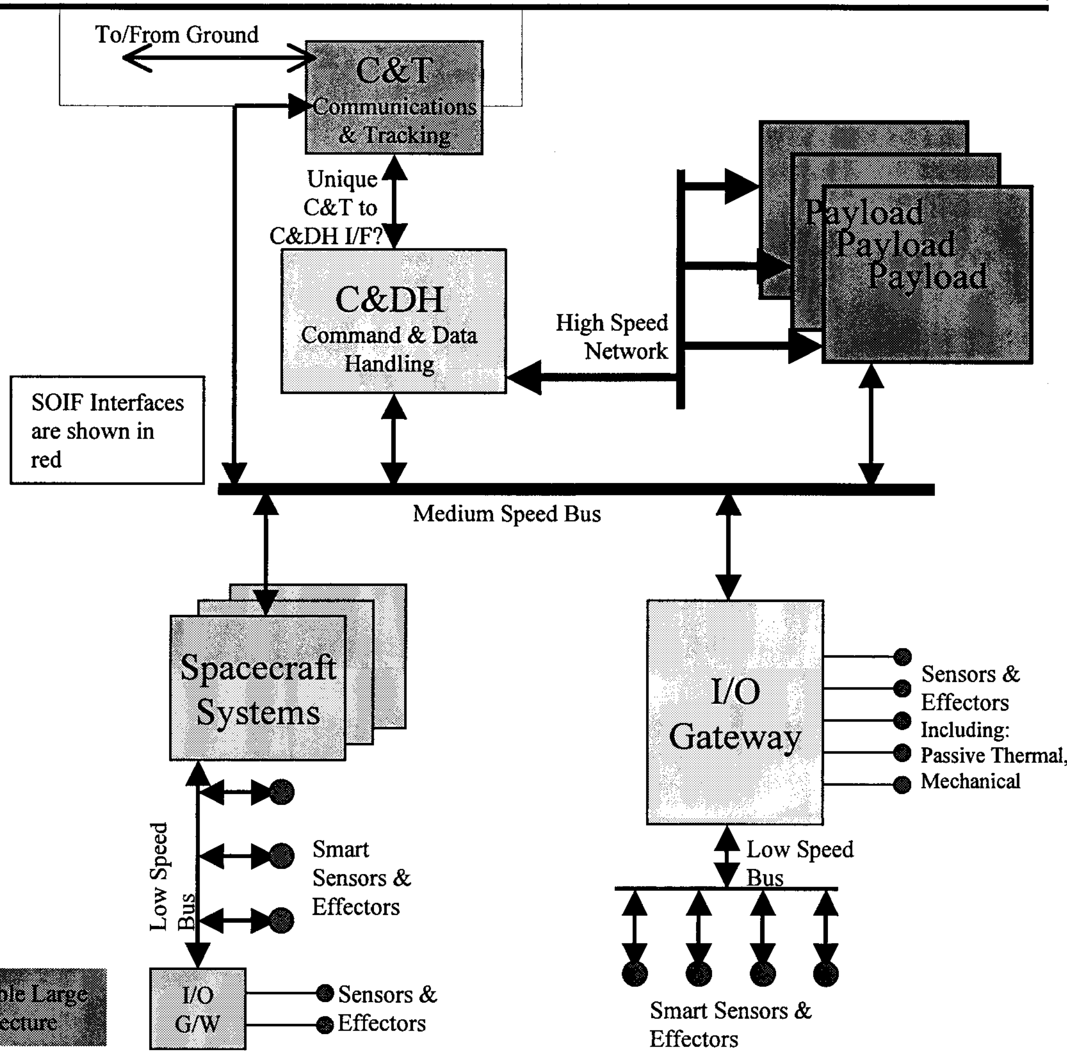
- Micro/Nano spacecraft can use medium- and low-speed busses
  - Medium-speed bus for backbone bus to interface to payloads, I/O gateways, and large sensors & effectors
  - Low-speed bus to interface to small sensors & effectors



Cartoon of possible Micro/Nano Spacecraft architecture

Physical Context of the SOIF: Large Spacecraft, Robotic & Inhabited

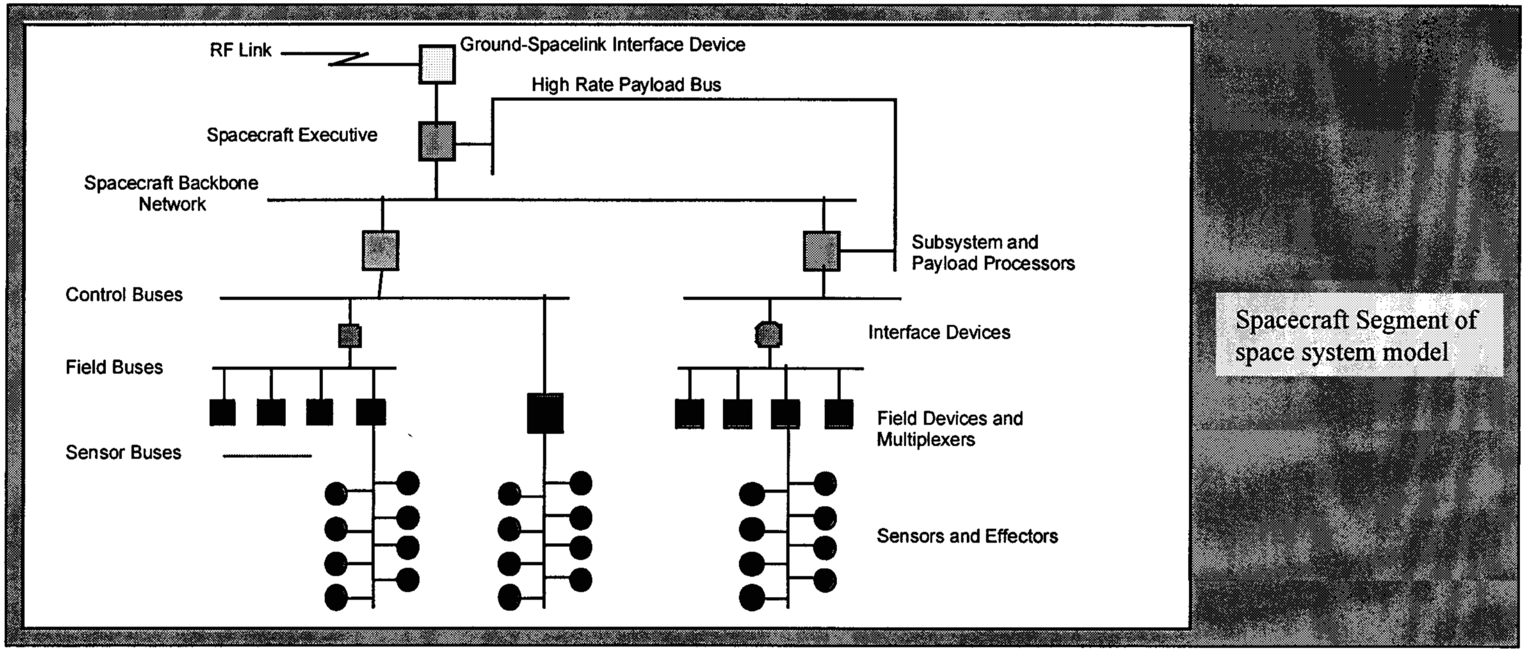
- Larger spacecraft may need busses with all three speed classes
  - High-speed busses needed for some payloads
  - Medium-speed busses will also need to interface with spacecraft subsystems
  - Low-speed busses still interface with sensors & effectors
- No difference in rqmts of large and small S/C busses



Cartoon of possible Large Spacecraft architecture

System Model: Spacecraft Segment

- Spacecraft segment can be modeled with various levels of busses, each with a different level of responsibility for running the spacecraft systems
- Devices interfacing to the busses vary from high speed payloads and the spacecraft executive processor to sensors and effectors

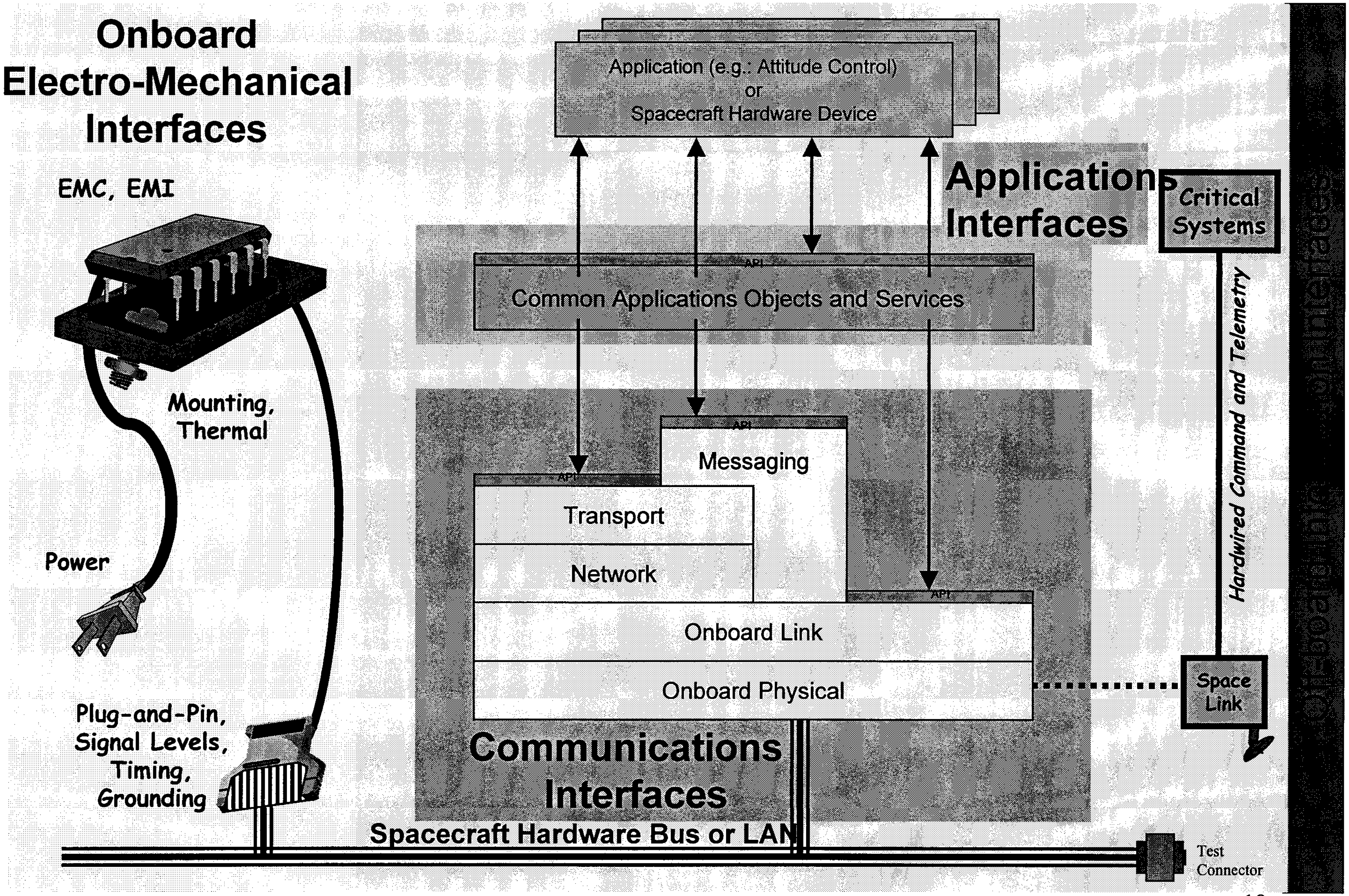


Elements of the SOIF Interface Reference Model

- Electro-Mechanical Interfaces
  - For electrical power, grounding, mechanical, thermal, and EMC/EMI interfaces and designs
  - Will propose only electrical power interface standards
- The Communications Interfaces
  - Propose an initial three-bus configuration for high-speed, medium-speed, and low-speed busses for API at Link layer
  - New busses to be proposed later to keep up with new technology
  - Will also propose Transport layer API, and Application layer API for messaging service
- The Applications Service Interface
  - Common Applications Objects and Services (CAOS) to be determined for API at Application layer
  - Know that time distribution and synch is one of the CAOS
- Communications is provided to either an application or a S/C device

API = Applications Programming Interface

Interface Reference Model: 99-NOV-12



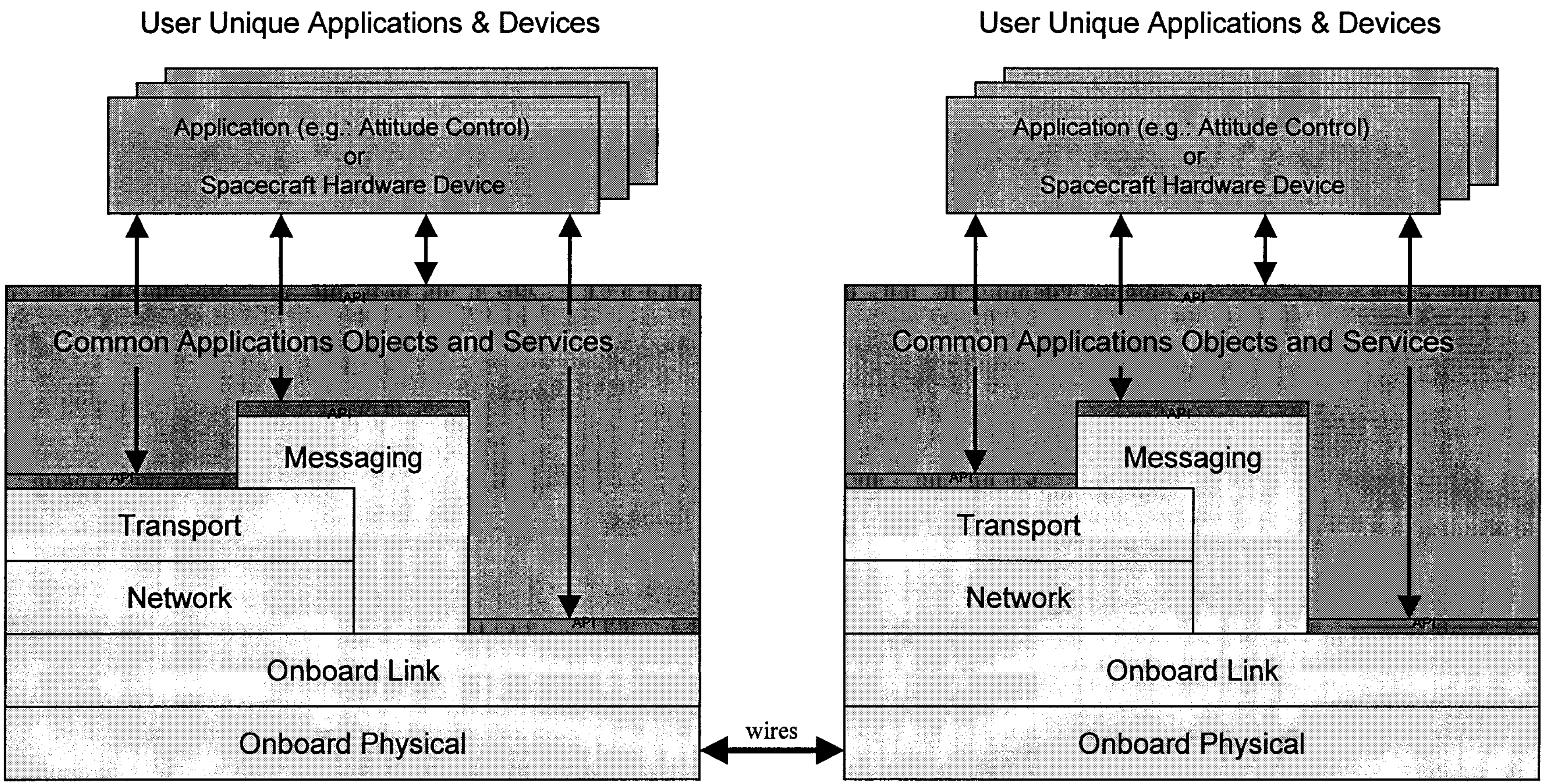
Electro-Mechanical Interfaces

- Will select and develop three power interfaces
  - +5VDC power for micro/nano spacecraft (such as Nanosat)
  - +28VDC power for medium and large sized spacecraft (such as MIDEX, EO-x, and TRMM)
  - +120VDC power for large, high power spacecraft (as is used on the International Space Station)
- Other electro-mechanical interfaces will be deferred to later, or taken up by other standards organizations

Communications for Applications & Devices

- For this discussion will ignore the differences between communications interfaces and application service interface
- Purpose of the communications interfaces is to provide communications between application and/or devices
  - Can be an application (flight software) running on a processor
  - Can be a hardware device (star tracker, temperature sensor), sometimes called sensor/effector or sensor/actuator
- The application/device can access communications and application interfaces directly
  - Use a Messaging, Transport, or Link layer API; depending on need and capabilities of the application/device
  - The application service interface would be available for applications or devices that would have the sophistication to take advantage of the services

Communications for Applications & Devices



Communications will be between a pair of applications, or between an application and a spacecraft device

Communications Interfaces: Link Layer API

- The Link layer API is the least sophisticated interface
  - A simple hardware device will usually use the Link layer API
  - Telecommand and telemetry packets will usually use the Link layer API
  - Link layer API will probably be defined first, so will be used by earlier projects
  - Is closest to bus interface used by most flight software today
  - Recommended have three different busses available from Link layer
    - Suggested high-speed bus is IEEE-1394
    - Suggested medium-speed bus is MIL-STD-1553B
    - Suggested low-speed bus is I^2C
  - Link layer API would provide identical interface to all three busses, insulating bus design and changes in technology from higher layers

Communications Interfaces: Transport Layer and Messaging APIs

- The Transport layer API will provide access to Transport and Network layer services
  - Network services include routing, congestion control, and internetworking
  - Transport services include multiplexing, segmentation, flow control, and congestion management
  - These services should only be needed for movement of data to another network, or off of the spacecraft (but not telemetry or telecommand)
- The Application layer API provides the messaging service
  - Messaging service provides consistent formats for data and messages
    - Predefined data types and formats for these data types
    - Consistent message formats for moving parameters (data) and defined events
  - Providing messaging services for data/devices or for applications
  - Messaging can support a mechanism to poll and discover devices on bus at initialization
  - The messaging service is provided directly to the Link or Transport layer as required

Application Service Interface

- The application/device can access communications interfaces directly
  - Use a Messaging, Transport, or Link layer API; depending on need
  - Also have Common Applications Objects and Services (CAOS) available for use by applications and devices
- Common Applications Objects and Services (CAOS) will provide common methods for communications between applications and devices
  - These objects and services will need to be defined after an analysis of spacecraft applications needs
  - Time distribution and synchronization is one of these services

Issues

- System Firmware: Automate device initialization and electronic data sheets, but not clear how (or if) this fits into the SOIF work
- Test Port: would like to recommend a test port, however not yet clear how this fits into SOIF work
- Spacecraft Constellations: insufficient time to understand how this subject will effect the SOIF work